HAF: An Operational, Event-driven Solar Wind Forecast Model

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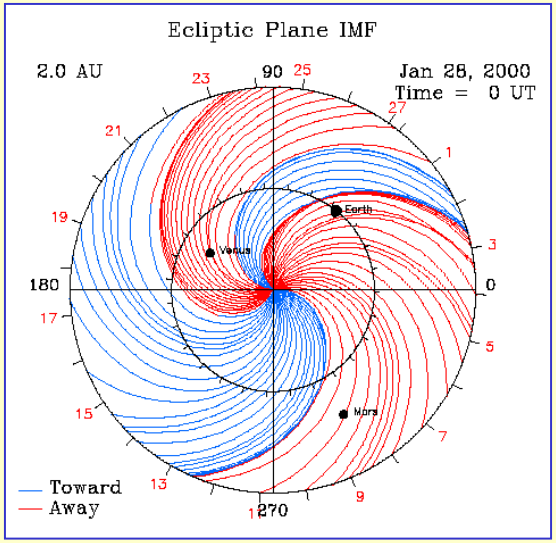
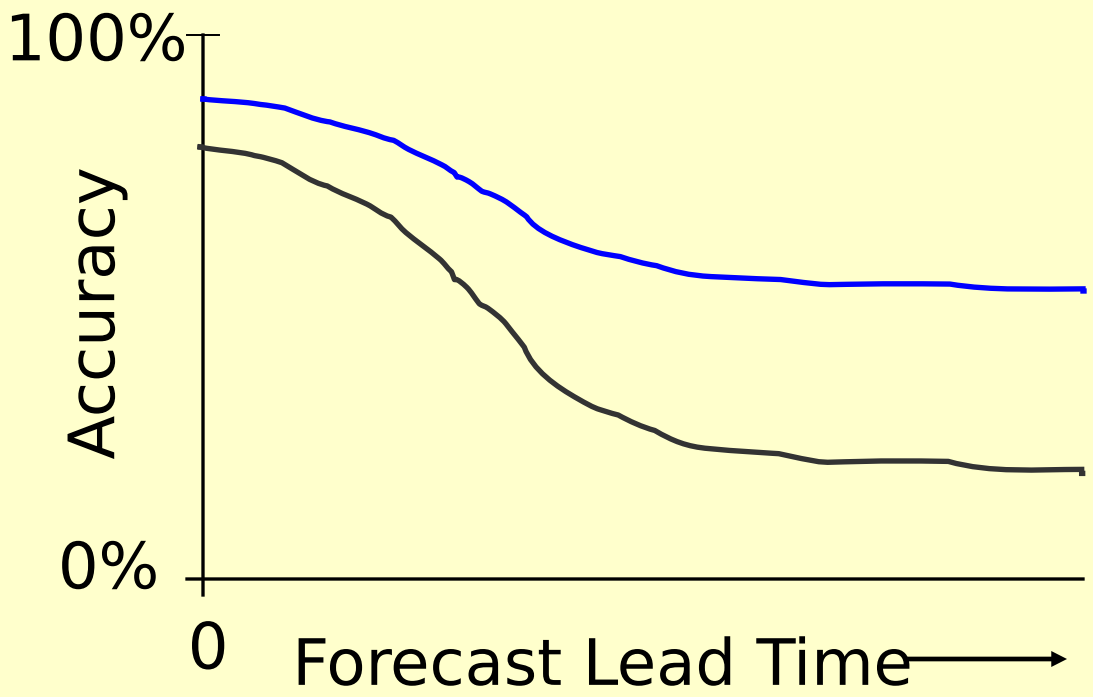
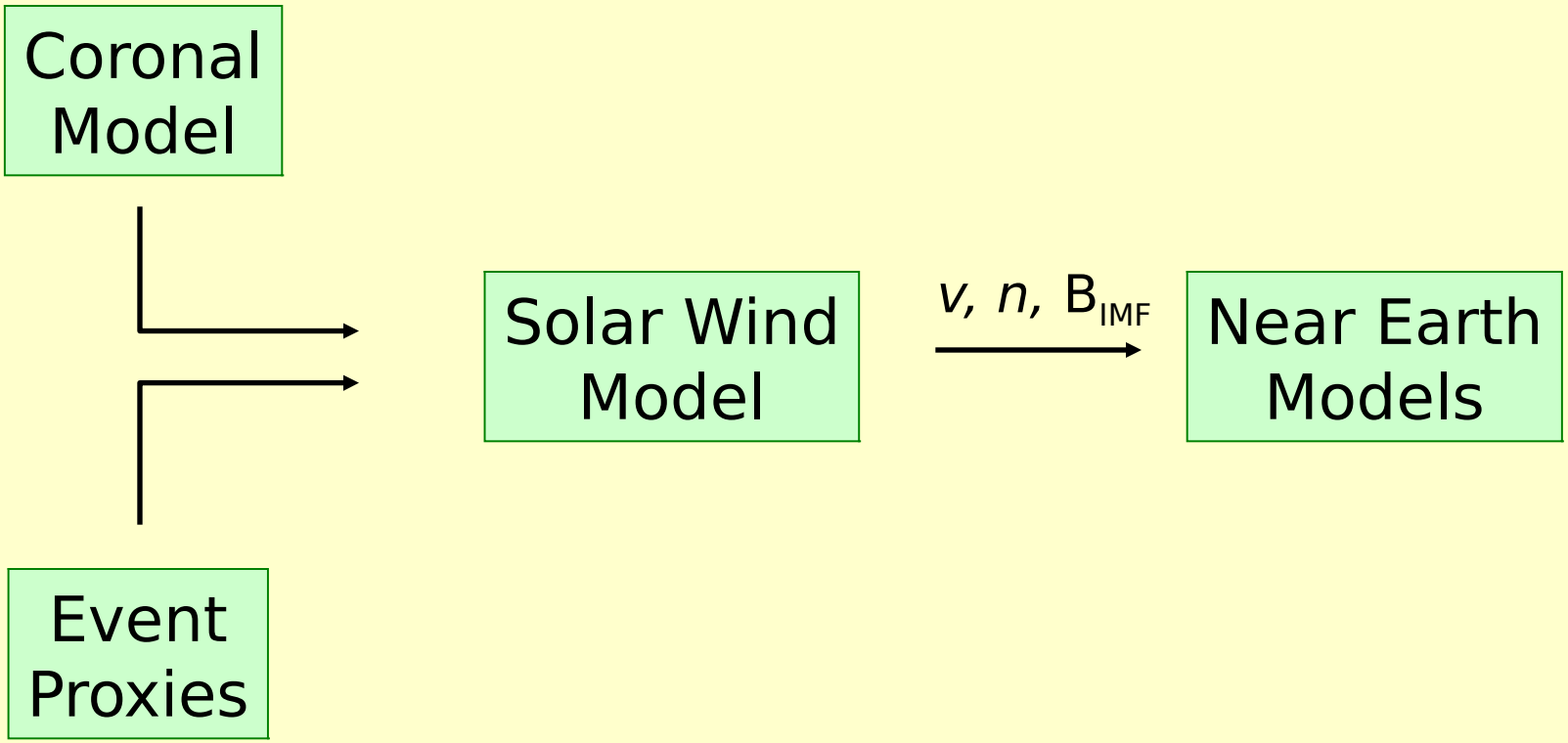


Goal: Improve Space Weather Forecasting



Geomagnetic Storm Prediction System



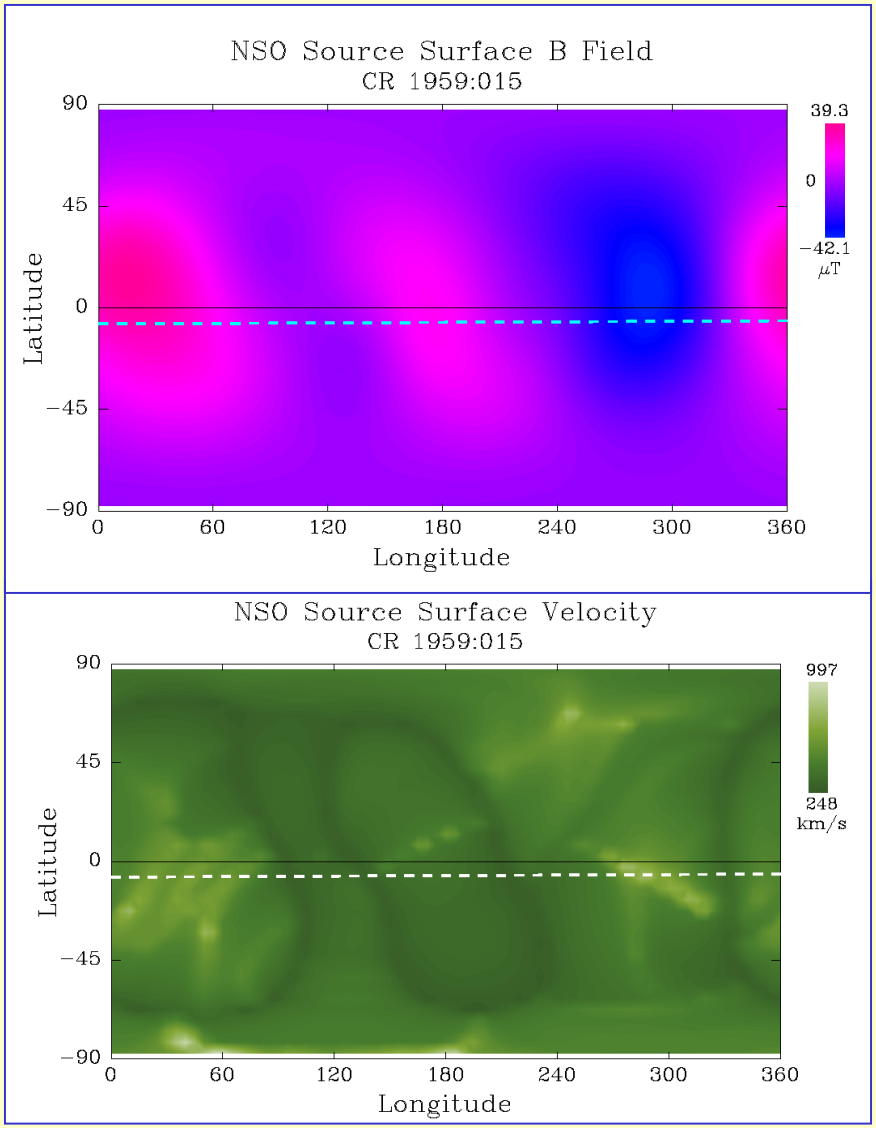
HAF Model Inputs: Ambient Solar Wind

Steady State:

- Source surface (2.5 Rs)
- *B*, *v* synoptic maps

Maps from:

- SEC (*Arge & Pizzo*)
- Solar observatories (NSO, MWO, WSO)



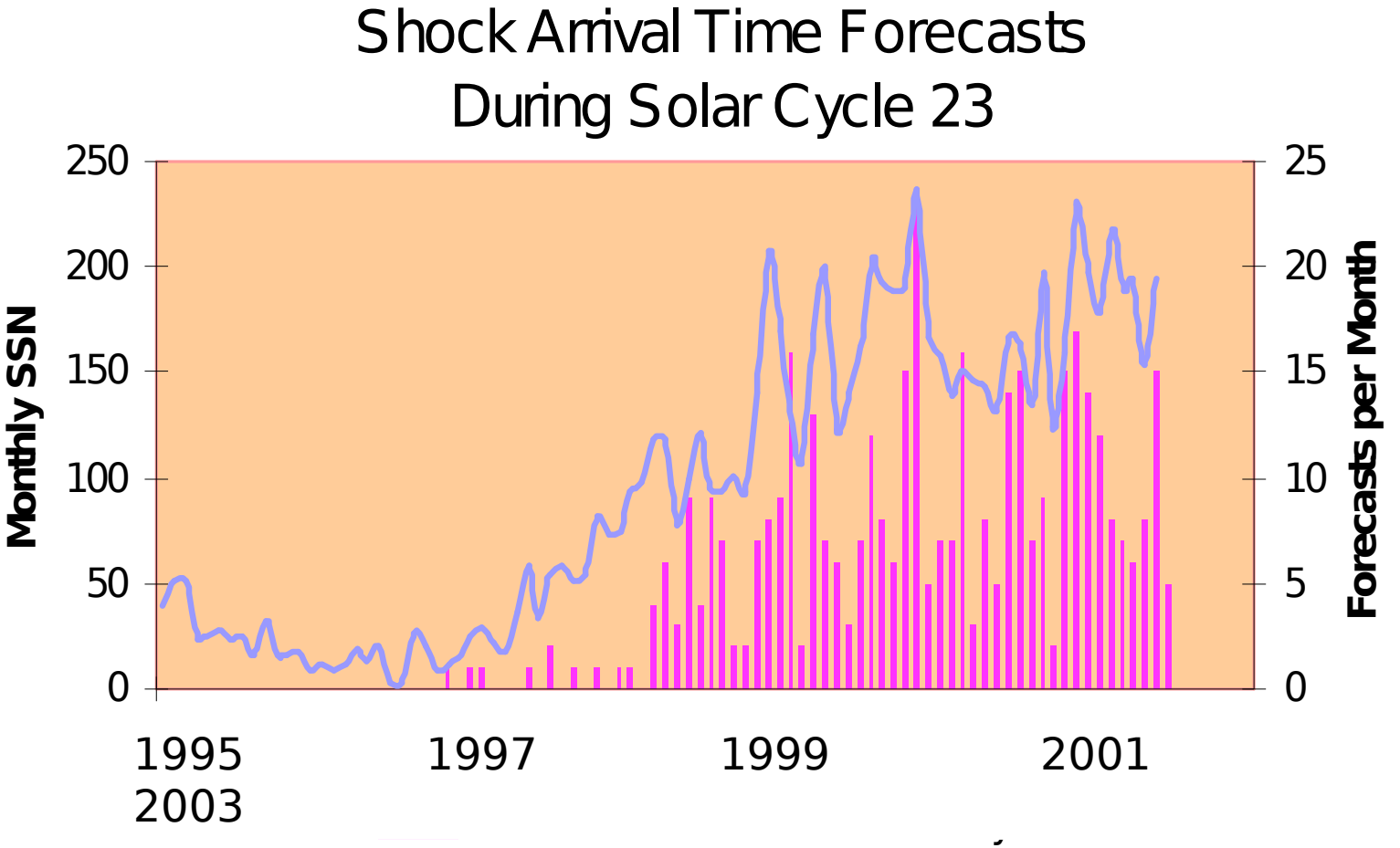
HAF Model Inputs: Solar Events

Required Input	Observation
Start time eg., 20010825 1642	GOES X-ray or metric type II radio event start time
Location, eg., N20 W34	H-alpha or active region report
Initial shock speed, V_S	Metric type II radio report or spectra
Duration, τ	GOES X-ray flux temporal profile

“Fearless Forecast” Study

- NOAA/SEC, EXPI, GI/UAF
- February 1997 - present
- Interplanetary shock arrival time (SAT) at Earth
- Ensemble of three models (HAF, ISPM, STOA)
- Benchmark forecast skill

“Fearless Forecast” Study



“April Fools Day” 2001 Events

Events

FF#	Start date/time	Vs	Location	Comment
254	20010327 1632	677	N22 E33	M2.2/1N
255*	20010328 1240	1000*	N18 E02	M4.3/SF
256	20010329 1004	1300	N16 W12	X1.7/1N
257*	20010330 1559	1850	S10 W90*	Blowout?
258*	20010330 1620	1600	S10 E115?	Blowout?

Forecast #256 issued 29 March 2001, 2055 UT

HAFv.2: Shock will overtake the two previous interplanetary ICMEs, and the combined structure's **shock will arrive at 1800 UT, 30 March 2001.** SSI = 1.0, and delta(dynamic pressure) = 13.2 nPa.

“FF” #255-258, issued Mar. 28-30, 2001

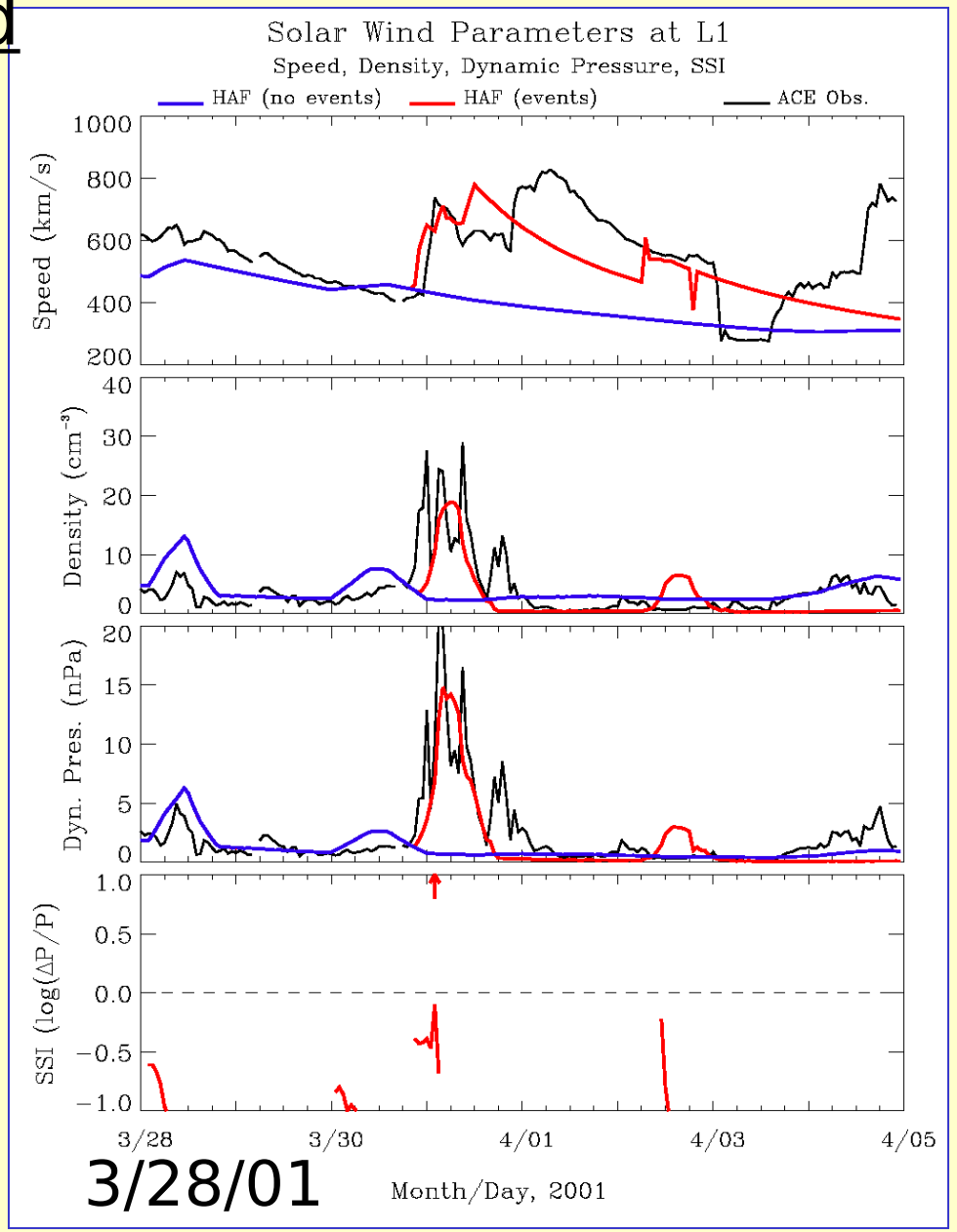
Speed

Density

HAF Model Prediction

Dynamic pressure

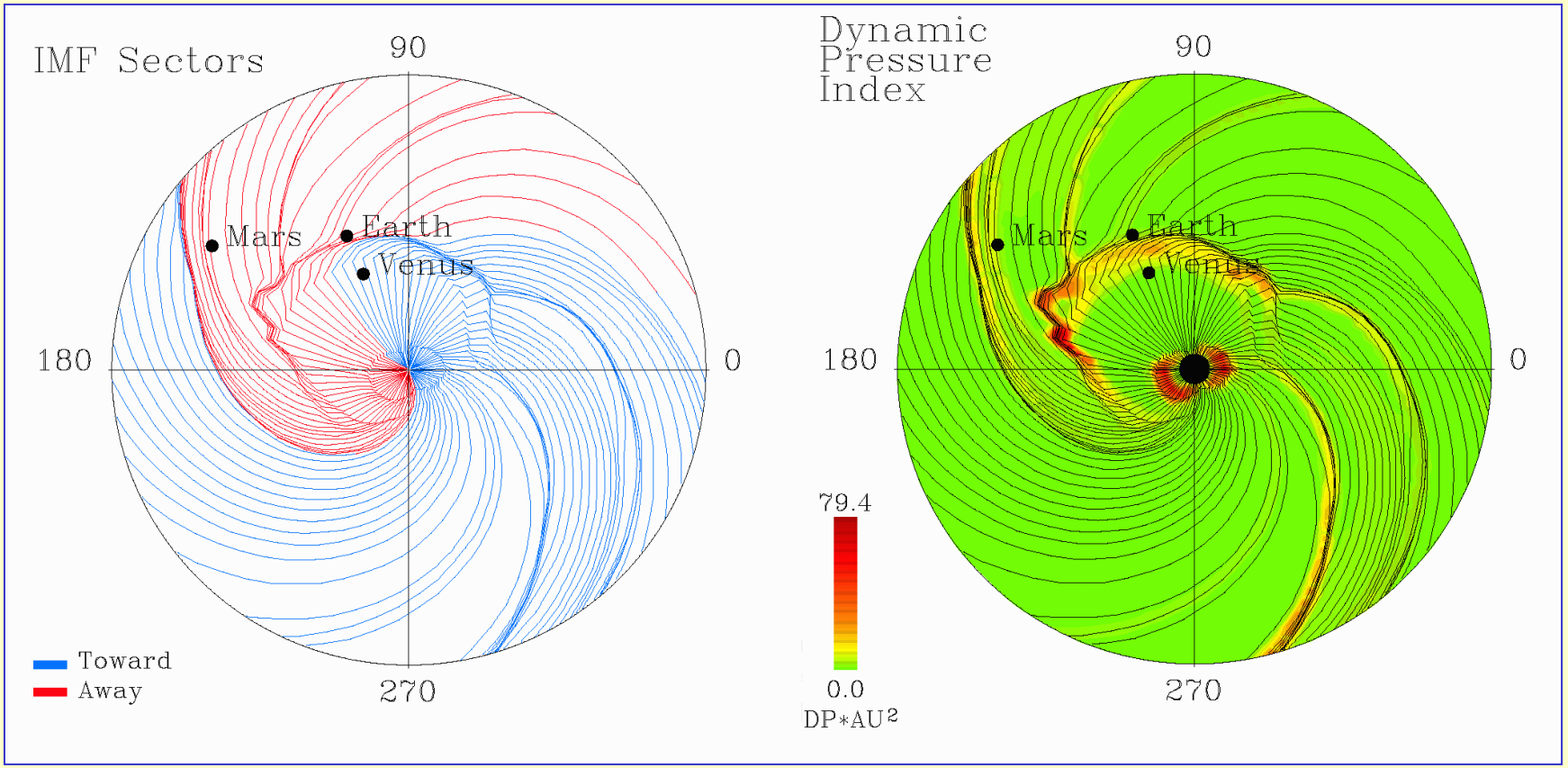
Log(ΔP/P)



3/28/01

4/05/01

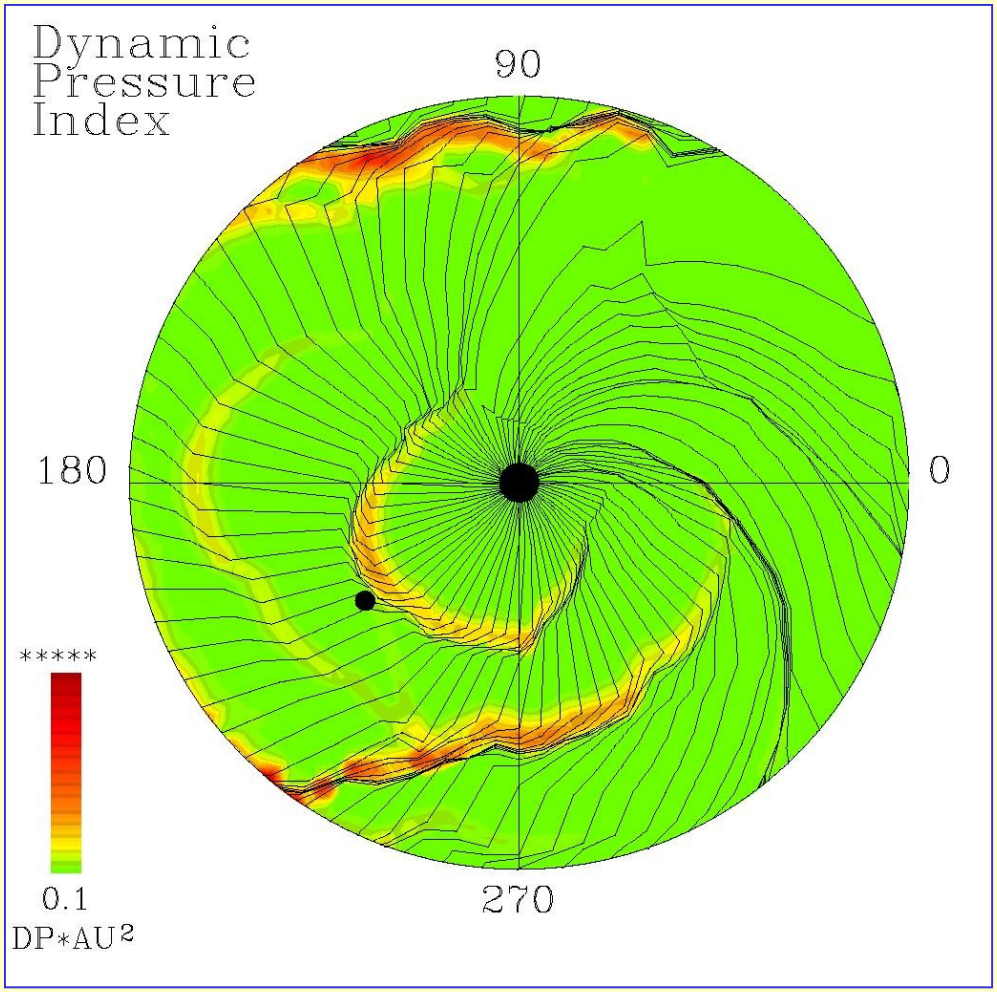
“April Fools Day” 2001 Event



“Bastille Day” 2000 Event

“Fearless Forecast” issued
at 20:31 UT
on July 14, 2000:

“Strong shock will arrive
at 15 UT
on July 15, 2000.”



[*Dryer et al., Solar Phys.*, 2001]

“Fearless Forecast” Metrics

Contingency Table

	Observed	
Forecast	Yes	No
Yes	***hit***	***false alarm***
No	***miss***	***correct null***

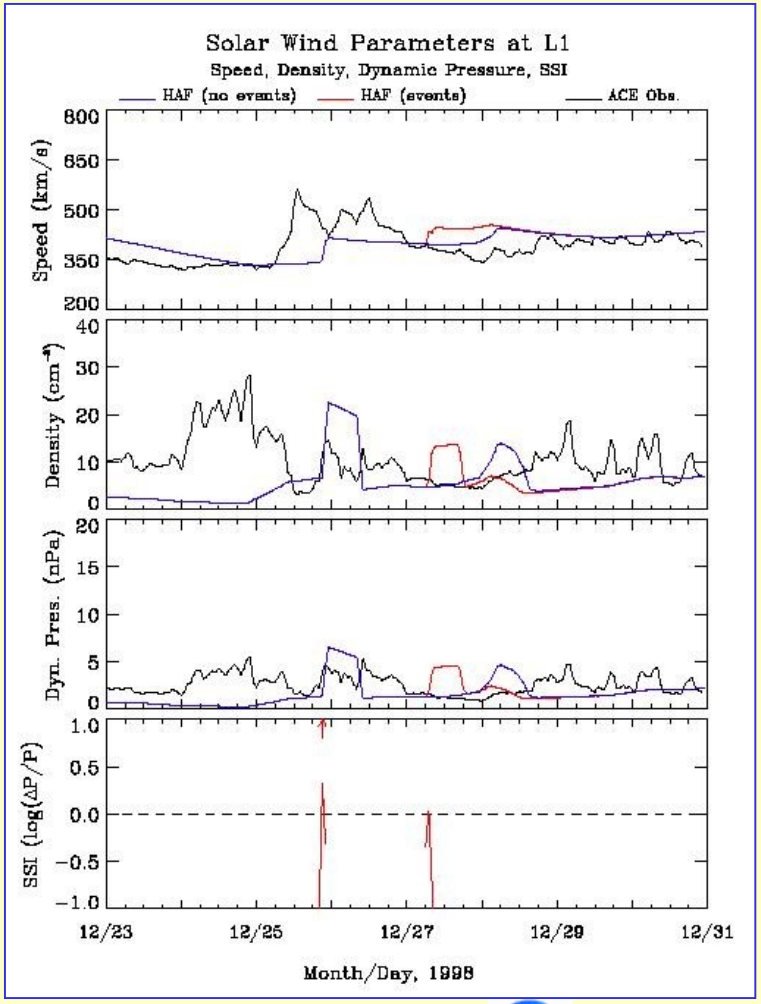
“Fearless Forecast” Metrics
Feb. 1997 - Oct. 2000

173 events, 68 observed shocks

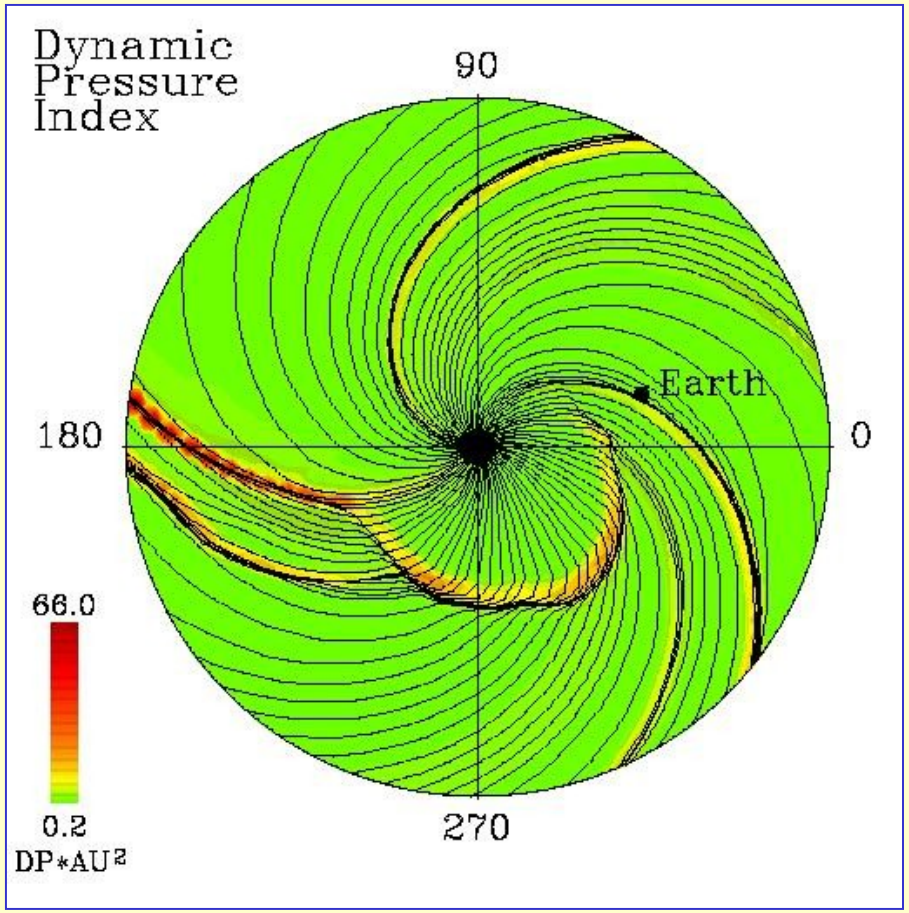
- Success rate > 50 %
- False alarm rate ~ 50%
- Hit/Miss Ratio STOA best for strong shocks
  HAF best for medium, weak shocks
- Heidke skill score ~ .15 - .20
- RMS error ΔT (SAT_{PRED} - SAT_{OBS}) ~ 11 - 12 hours

Solar Cycle 23 - Lessons Learned

- CIRs produce shocks.



Dec. 25, 1998, 20 UT



Solar Cycle 23 - Lessons Learned

- Initial shock speed is the most important input to the SAT prediction.
- SAT forecast skill is best near Central Meridian.
- SAT forecast skill is worst for limb events because Metric Type II speeds are too low.

Future of Operational, Real-Time, Sun-to-Earth Solar Wind Predictions

Better Customer Collaboration:
- Specify Needs

+

Improved Forecast Skill:
- Assimilate Data
- Predict B_z

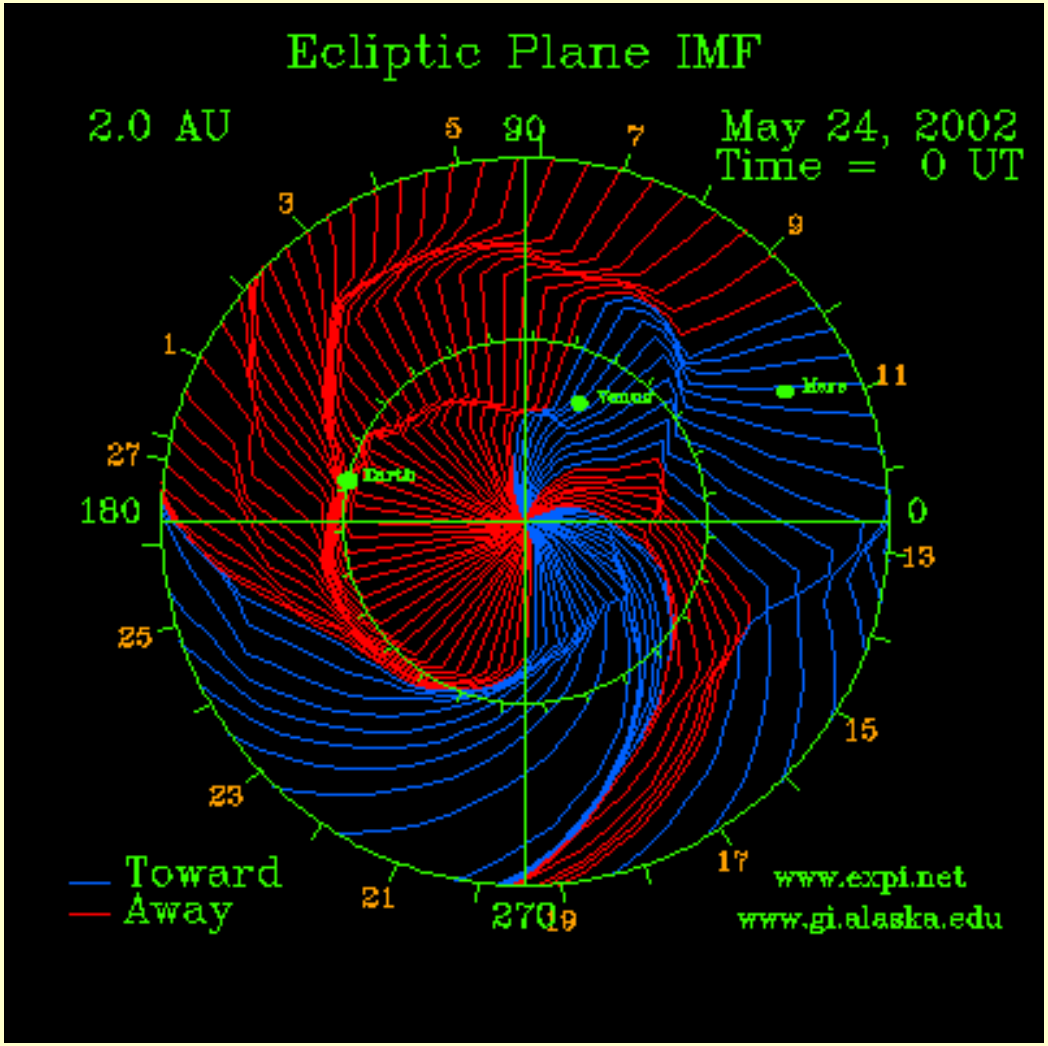
=

Increased Customer Support:
- Make Advanced Operational Decisions

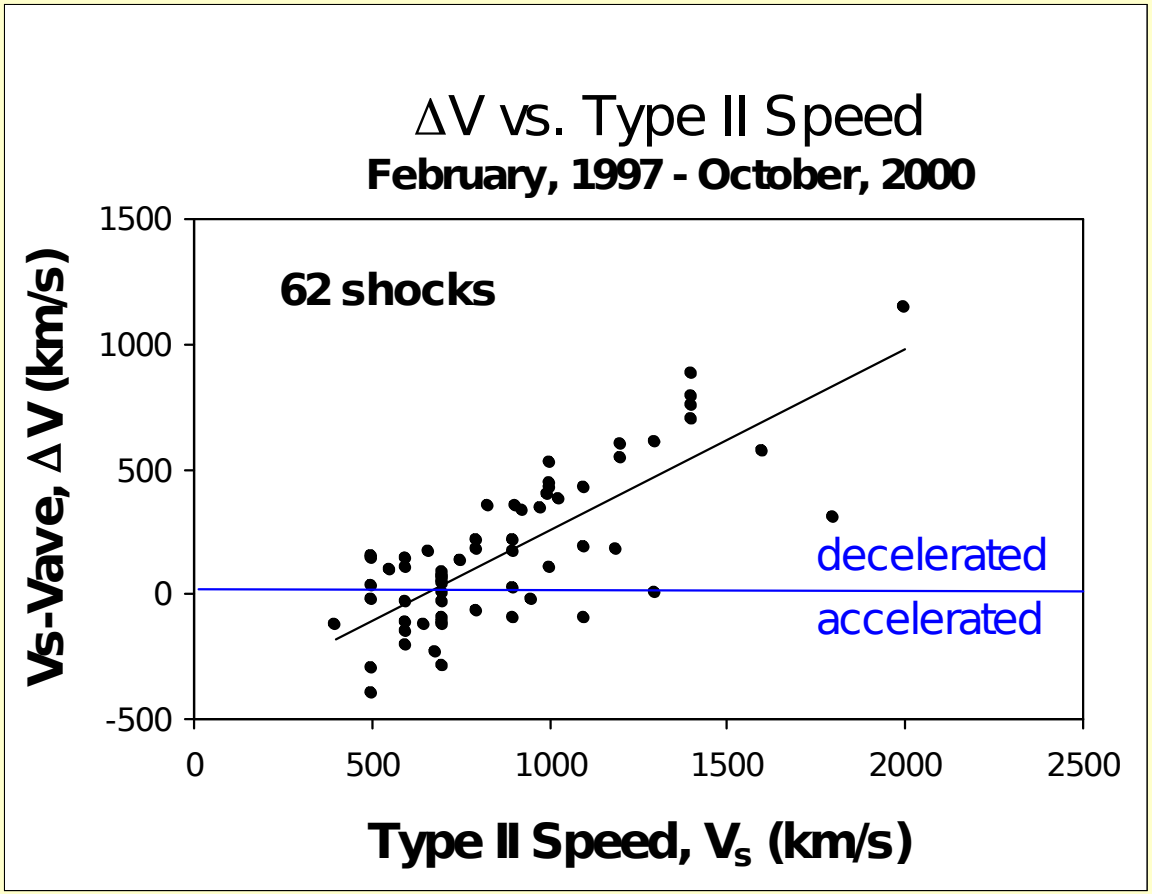
“Fearless Forecast” Web Site

http://gse.gi.alaska.edu

Email: gfry@expi.com



Metric Type II Speed



Hakamada-Akasofu-Fry (HAF) Solar Wind Model

- Provides realistic background and event-driven solar wind conditions at L1 and elsewhere.
- Takes in solar observations and event reports.
- Uses “modified kinematic” approach to track solar wind fluid parcels.
- Predicts interplanetary shocks in the global heliosphere.
- Drives downstream empirical and first-principle space